

**Science in the Preschool Classroom:
Why and How This Can Be a Teacher's Best Friend**

Front Porch Series Broadcast Calls

I'm Gail Joseph, Co-Director of the National Center on Quality Teaching and Learning. And on behalf of my colleagues and I at NCQTL, I'd like to welcome all of you to our broadcast call today. Our Front Porch Series, as many of you know, is a collection of broadcast conference calls that take place on the fourth Monday of every month, unless there's a holiday, where we gather to hear a national expert on a topic related to quality teaching and learning and young children. Today we focus on the topic of early science.

And it is an honor and a delight to introduce our featured speaker to help us think about science and young children. Dr. Daryl Greenfield is a nationally recognized expert in early childhood research. We're very lucky to have him. He's a professor of psychology and pediatrics at the University of Miami in the beautiful Coral Gables, Florida. So Region IV is in the house, as we like to say. Dr. Greenfield has participated in a number of statewide initiatives, including being an advisor to the Florida Office of Early Learning. He was a member of the task force that created Florida's early learning standards – those of you in Florida I'm sure are very familiar – and a member of the steering committee for the Florida Head Start Association Research Committee.

For the past three decades now, Dr. Greenfield's research has focused on using data to inform program practices to improve school readiness of low-income minority children served by programs such as Head Start. Most recently, his focus has been on preschool science as a foundation for improving young children's school readiness; in fact, connecting his work in early science to improved instructional support scores on the CLASS.

In addition to ACF, the National Science Foundation, and IES-funded projects with Head Start programs, developing and evaluating science and engineering curricula, studying the emergence of young children's questioning skills – very interesting – and creating adaptive assessments of Head Start children's science knowledge and skills using touch-screen computer tablet technology. And these are all things we want to learn more about. And so now, without further ado, I am turning the mic and the screen over to Dr. Daryl Greenfield.

Dr. Daryl Greenfield: Thank you, Gail, for that nice introduction. And I want to also thank National Center on Quality Teaching and Learning for inviting me to do this, and the Office of Head Start. And I'm very excited that I'm going to be spending the next 45 minutes with all of you talking about one of my loves, Head Start and science. And I'm hoping by the time I'm done, half an hour from now, you are going to view science as I do, as potentially your best friend. I think some of you have already listened to some of the presentations of Front Porch, and I'm now the third person to talk about science as part of this series.

So what I thought I would do is instead of spending a lot of time going over what has already been covered, which I think is a nice main course, I'm hoping to present a bit of dessert for you today. And this is actually a picture of a dessert I had yesterday. There was a chocolate festival going on in Coral Gables last weekend, so I had more than my share of chocolate. And if you love chocolate, hopefully this will be a good dessert for you as well.

So what I'm going to spend my half an hour doing this afternoon, or in the morning if you're over on the west coast, is I want to just talk very, very briefly about this issue of school readiness. In other words, the "what" that is generating the curriculum and classroom activities that you're all fairly familiar with. I then want to spend just also a little bit of time talking about the "why" that underlies these classroom practices, with a little bit of information and sort of theories of early childhood development. Then I want to spend most of my half an hour talking about the "how" – preschool science and how that can improve multiple areas of children's school readiness and best practices.

So to begin with the "what," defining school readiness. We've been under this issue of school readiness for a number of years. It was 1990, 22 years ago, that Congress first passed education acts, the first of which was the School Readiness Act; and we've been looking at school readiness for this long period of time. And just sort of as an overview, although what we'll end up seeing is that there's been largely a focus on what children know and can do, readiness is not really just something that's inside the child. But rather, when we think about defining and even measuring school readiness, we also want to think about the influences of the home environment; to think about the influences of what's happening in the classroom, the classroom experiences for the children; the cultural context that underlies some of the issues of what children are going to be exposed to; what sort of resources are available in the community to – to help with school readiness; and also, the child's interactions with all of the individuals around him: his teachers, his parents, his peers, and even, in some cases, his pets.

Now, school readiness is really this very complex set of multiple sources of influence. But for the most part, beginning in 1990 and – and for 15 or so years, the real focus on school readiness has been assessing what preschool children know and can do. And for those of you in Head Start, you are very familiar with these now 11 school readiness domains – used to be 8 of them; now there are 11. And there's a major focus in terms of trying to cover these 11 readiness areas and making sure that Head Start children have some readiness in each of these areas. So even within the – the confines of just what children know and can do, it's not that children appear on the doorstep of kindergarten ready or not ready. There are multiple, multiple components of this readiness.

Why is this a focus? Well, we know from numerous studies and data that low-income preschool children are already behind their privileged peers in multiple school readiness areas before they enter school. And as you know, programs like Head Start and Early Head Start are really aimed at closing these gaps during the early childhood years so that there's a focus on trying to improve children's readiness when either they're in Head Start, if they're lucky enough to start the program at a very early age – birth to 3 – or at least in the last two years or the last year prior to going to kindergarten.

Now, as you also know, recently there has been an additional focus not just on what children know, but assessing the interactions that occur in classrooms. And you're all familiar with this Classroom Assessment Scoring System, or what is referred to as the CLASS, which really tries to attempt to measure the quality of the interactions that are occurring in the classroom. And the CLASS is set up to be measured on a 5-point scale: one – scores of one and two tend to be in the low range; there is a moderate range of scores of three, four, and five; and then a high range of scores of six and seven.

And within the CLASS, there are a number of dimensions that are part of three broadly defined domains, the first of which is referred to as emotional support. And these – these include dimensions such as having a positive climate in the classroom such that children feel safe and comfortable, that the teacher is – is sensitive to the needs of the children. Not only does a teacher acknowledge – the teaching staff

acknowledge the needs of the children, but they respond to them. And that there's a regard for student perspectives so that the teacher does not entirely dominate.

The teaching staff doesn't dominate everything that's – that's occurring in the classroom, but there is opportunity for children to have a perspective and that perspective to have an influence on what's going on in the classroom. And for the most part, when you look at programs, preschool programs across the country, and these are Head Start as well, there's typically fairly high levels of emotional support that you see in classrooms. So on this one to seven scale, lots of classrooms on average fall in the very high moderate range or – or the high range.

The second major domain of the CLASS is what's referred to as classroom organization. And the classroom organization looks at issues surrounding having a class that's well managed and running well. Children learn what the routines are. They learn how to internalize the rules of the classroom so there's not a lot of time spent on behavior management. There's a lot of high levels of productivity, which means that when learning is indeed occurring, there's not wasted time with the teachers and the teaching staff having to worry about misbehavior or managing behavior. And – and the lessons, as well as – as utilizing typically the children's 20-minute attention span, are also ones that are engaging to the children so the children are excited about learning and engaging. So if we have children that are exposed to 15 or 20 minutes a lesson in which there's no downtime and they're highly engaged and they're very interested, there's likely to be learning to – to occur.

Now, the third domain that's related to the CLASS is referred to as instructional support. And unfortunately, this is a domain that produces very, very low scores. So as emotional support, I said, is pretty high, five to six. Classroom organization is – is also at the high end of the moderate range. But when you look at instructional support, what you end up seeing is that instructional support is really at the low end.

So I want to spend just a couple minutes going into a little bit of detail about what instructional support is, because we're going to come back to this issue of instructional support when we start talking about science in – in the preschool classroom. So the first dimension within this domain is called concept development. And what it's trying to measure is the teacher's use of instructional discussions and activities that are promoting students' higher order thinking skills and cognition and focuses on teachers' understanding – the teacher to focus on children's understanding rather than simply rote instruction.

Here is an example of two women sitting, and one of them is really trying to make sure that her boyfriend understands the concept of why it's important to call her back. And the kinds of – of indicators that appear in these and the kinds of activities we're looking for is the teaching staff focusing on children's understanding of concepts, encouraging them to use analysis and reasoning skills, promoting the exploration of concepts, linking concepts across different activities so children don't see these as isolated pieces of information, and – and to apply these concepts to the real world.

The second aspect of instructional support – second dimension – is referred to as quality of feedback. And what this tries to assess is – is the degree to which the teacher is providing feedback that expands learning and understanding and encourages continued participation on the part of the children. And the kinds of activities you're looking for here are scaffolding, you know, trying to move children into areas where they're not able to go on their own; to create feedback loops instead of giving children just single-word answers to questions that cut off the interaction; to create feedback loops to prompt the children

to answer their own questions by engaging them in thinking processes; providing information, you know, in gaps where children don't have that; and encouraging the children to engage in these conversations and this feedback.

And then the last area of instructional support is referred to as language modeling. And what you have here is the ability to capture the quality and the amount of the teacher's use of language stimulation and language facilitating techniques. So, having classrooms where there's frequent conversations; having open-ended questions to stimulate conversation and language; for teachers to repeat and expand on both what they say and what the teachers – excuse me, what the children say; to have self and parallel talk; and to introduce advanced language, but to do it in the context of what the children understand, and to use language that the children can understand already to introduce that advanced language.

I want to now move very, very briefly to talk about the "why" of these particular classroom practices. Why is it important to have these sorts of classroom practices? And I know you can't see me since this is a webinar, so I took a picture of me teaching one of my classes. I am the tomato on the left. And I want to briefly talk about three particular approaches that have influence on what's happening in – in preschool classrooms.

The first, which I'm sure many of you know about, is Piaget's theory. And when you ask from Piaget's perspective why is development occurring, what is going on in terms of child development, what Piaget says is that there are these two complementary but opposite processes, one of which he calls assimilation. The term "assimilate" typically means to take things in. So what children are doing is they're beginning with a series of structures – cognitive structures in their head that Piaget refers to as "schema." And Piaget argues that young children, even at birth, have an intrinsic motivation to seek out the novel that's in their environment. And what they end up doing is, in seeking out and exploring novelty in their environment, they're adding this new information to the schema that they already have.

And Piaget says that the kinds of information that's most attractive to young children – and, I mean, this is true of anyone who's learning – is something that's moderately novel. So it's not something that I almost already know really, really well, and it's also something that's not so far away from my knowledge that I really can't make any sense out of it. But it's something moderate, which in some sense, if you think about this, implies that it's building on my existing knowledge. It's – it's related to something that I know, but it is indeed novel. And according to Piaget, what ends up happening, this assimilation process ends up bringing new information into these schema, these cognitive structures; and because it's new, the information is not going to fit perfectly. Because if it did fit perfectly, it wouldn't end up being new.

What then happens is a complementary process that Piaget refers to as accommodation. And what is occurring in this accommodation process is that, according to Piaget, children are uncomfortable with the discrepancies that they have in their schema, and there's now an intrinsic motivation to try to resolve these discrepancies, to make sense out of the differences that have occurred because there's information now here that doesn't quite fit. And this accommodation process leads to changes in the structure so that the new information now fits. It's no longer novel; it's now familiar. And this particular sort of process then leads to changes in the structure in which the structures become more and more developed, more and more advanced. And as a consequence, children end up learning.

Now, from Piaget's perspective, what happens then when you do this? Since he argues that children are an active participant in this process, then according to Piaget, the role of the teacher – and you can see this to – to a great extent in early childhood classrooms – is, since a child is – a child's development is occurring through this internal, active engagement with his or her environment, the role of the teacher or the adult is to provide the child with a stimulating or novel environment to explore. So here is an example where once this door is open to the refrigerator, the child is on his or her own because he's intrinsically interested in what's in there and will explore and learn from this exploration.

Now, a second important perspective on what happens and why this development occurs is the perspective of a Russian psychologist named Vygotsky. Now, what Vygotsky says, which is in some sense different from Piaget, is that what adults need to do is they need to scaffold children into a zone of proximal development. And what we have here in this little picture that – that I've included is that in the middle with this flower is our friend Alvin the chipmunk, and sitting on the log is his girlfriend Brittany. Now, he's stuck up on – on the branch, or the – I guess it's a branch, and Brittany's down on the log. And what his teacher is doing is providing a scaffolding into the zone of proximal development so that Alvin is actually able to provide his girlfriend Brittany with this particular flower.

So what the – what adult is doing is closing the gap, moving the child into that zone of proximal development to help guide, through kind of a hands-on apprenticeship, the learning of this particular activity. So from Vygotsky's perspective, the role of teacher is then that the adult must know the sequences of steps that children will follow in learning a new skill. And then the role of the adult, unlike in Piaget where it's simply setting up the environment and letting the child then actively explore, for Vygotsky the role of the adult becomes much more interactive in that the adult now needs to scaffold the child into this zone of proximal development.

I want to briefly talk about one more approach, which is a fairly recent approach, of a psychologist named Michelle Chouinard, who published this monograph back in 2007 focusing on children's questions, arguing that children's interest and questions produce a mechanism for cognitive development. And what Michelle did was she looked at a series of studies to determine: do children ask questions starting at a very, very young age, and why? What's the purpose? So do young children ask questions? She wants to know the answer to that. If yes, what is the content and focus of these particular questions? And her monograph reviews multiple studies with both small and large groups of children to answer these particular questions.

Now, I'm not going to go into great depth on this monograph. It's a very interesting monograph. I just want to point out that the types of questions that she's attending to are, first of all, information-seeking questions. So, to what extent are – are these young children, and these are from the time children first are able to talk, are they looking – are they asking questions that seek out information? They can either be factual, an isolated piece of information; or explanatory, that involve more causal relationships; or they might be non-information-seeking questions just to get attention, to clarify, to ask permission to do something.

And what Michelle was able to uncover in this research is that, for the most part, children are asking questions to find out information. So when they have gaps, when they have inconsistencies or problems in their own knowledge is when children typically ask questions. They're asking largely, to a much, much greater extent, explanatory questions. And what ends up happening, which is nice, parents for the most part give answers to the children when they ask these questions. But what you see is that if the parents don't give answers, children don't give up; they persist.

The other thing that – that you find is that if the parent provides a factual answer and ends the conversation, then the conversation typically is over at that point. But if the parent involves the child in back-and-forth exchanges and does this feedback loop, what you find is that the initial question that the child asked, which is often about a fact, ends up leading to an exchange that moves from fact to explanation. And what Michelle wants to argue, and I agree with her, is that young children's questions are powerful tools for gathering information and advancing children's cognitive development.

So in looking at these three particular theories, what are the implications for – for classroom interactions? And what these three theories would say is that, in the classroom, what staff should be doing is providing stimulating environments for children's active exploration. They should go beyond that and guide this exploration into the children's zone of proximal development. And also not to be entirely directive, but encourage children to ask questions, extending these interchanges to move from factual knowledge to a more in-depth understanding on the part of the children.

Okay, so now I want to finally move into talking about science. And given all of these issues, you have lots and lots of readiness domains that need to be covered, lots of activities to do and think about in terms of how to organize and structure the interactions and – and the environment in your classroom. A lot of choices. Where do you start?

So I'm going to come back to the CLASS, and I want to show you potentially what might be happening in – in a classroom during the day and how the CLASS typically scores that. So suppose this is the nature of the interactions that are occurring in, say, a Head Start classroom during the day. So circle time, maybe there's a little bit of – bit of instructional support. Then the kids go off and are brushing their teeth; there's probably not much going on. Then there's choice time, and maybe that goes up. Then there's clean-up; maybe that goes down. There's a small group activity, and that might lead to very high levels of – of instructional support. Transitioning, might go down again.

But what ends up happening is when you score the CLASS, you walk into the classroom, you observe for 20 minutes, you score for 10, you observe for another 20, you score for 10. And the class score of a teacher that has this variability would be the line – the average line cutting across all that variability. You might have another teacher who also shows variability. It might be less than the first teacher, but because of the way we score the CLASS, those two teachers would look pretty much identical. So one of the things that we were thinking about in the research that we were doing is that these episodes of high quality that actually are already occurring might be obscured by the fact that they're not being isolated in terms of how we do CLASS observations.

So one of my former graduate students, Janna Fuccillo, who I believe is on this call and has finished her dissertation, defended it, and is now working in Boston. Probably cold up there, Janna; right? What Janna did for her dissertation is she said, "Let's see if we can try to get a hang – a hold of these particular instances where there might be higher levels of instructional support." And she decided a good place to start would be teacher-directed activities, because during teacher-directed activities, a teacher is focusing on building skills, they're more likely to potentially encourage verbal participation, extend feedback, and conceptual development. What are typical types of teacher-directed activities? Book reading, hopefully science, likely math, and always circle time.

So what Janna did for her dissertation is we asked 24 of our Head Start teachers in our – in our Miami-Dade County Head Start program to allow us to videotape them. And we asked that we could videotape

them on a typical circle time, a typical math lesson, a typical science lesson, and with them reading a particular book. And we all gave – we gave them all this book, "Edward the Emu," because we knew that it was developmentally appropriate and no one was using it. And we asked them to look at it in advance if you'd like, review it, but let us videotape the first time you read that book to the children in your classroom.

So what we ended up having as a data set when we were done with collecting these data was 24 teachers, each of whom independently provided us four videos: one just about circle time, 20 minutes or so; one with about a 20-minute math lesson; one with about a 20-minute science lesson; and one with about a 20-minute storybook lesson.

And then what we did is we – we took our undergraduate students and we trained them to be reliable CLASS coders. We gave them all three domains and all 10 CLASS dimensions to code. We told them nothing about why we did this study. They had no idea what the data were about. They were just asked to learn how and to code the CLASS. Then we had 20 of the 96 videotapes double-coded just to make sure that we were getting reliability. And we had very, very high reliability, 87 percent, for these videos.

So what did we find? When you look at emotional support and classroom organization, you find, as you expect, pretty high scores and no significant differences between any of the activities. So you see to the – to the left of the graph circle time, math next, science next, story time. These all are pretty high, and there's absolutely no difference in emotional support or classroom organization for any of those four activities.

Now, however, take a look at what happens for instructional support. We're going to start looking at these four activities, starting off at the left, looking first at the green bars, which are concept development. As a reminder, we're getting at higher order thinking skills, focusing on understanding rather than rote learning. And what you see is that green bar under science is indeed higher than the others. It's significantly higher than what you see for the storybook reading. And the storybook reading is also higher than the math and the circle, which didn't differ.

Next, look at the – at the middle, the kind of bluish one, quality of feedback, the middle – middle graph in each of the four. As a reminder, quality of feedback has to do with expanding learning and understanding, encouraging continued participation. And again, science produces the highest level of this. So science is higher than – the interactions for science are higher than occurs either in reading the – the story, the math, or the circle time.

And then finally, if you look at the last bar, the yellow one, this is language modeling. Again, this is about frequent conversations in advanced language. What you see is that science and storybook reading are the highest. You might imagine that there should be good language modeling when you're reading a story. But again, math and circle time are lower than science and story time. Now, I want to point out that these are not fantastic science lessons. It's not that these are scientists teaching science lessons. These are Head Start teachers who are not really familiar with science. The science was all right, but not great. But what we're seeing is that even when you do science and it's not necessarily a great science lesson, you're getting higher levels of instructional support.

So why is that? Why would science end up producing higher levels of instructional support? Well, one way to think about this is that science is a natural entry point for the core components of high-quality instructional support. So when you're doing science, it's a fertile ground for promoting concept

development. You're learning some new concept. You're trying to engage the children in the activity. You're introducing new – new language. I'm beginning to answer some of the questions I included as sort of what are the – what are the most frequently asked questions that I get.

So science... But won't my children also find science hard and uninteresting as I did when I took science in school? And the answer is, no, they will not, because one – one of the things that's true about young preschoolers is that they have a natural curiosity about their world. They want to know how their world works. They want to know, you know, why does the sun come up? Why does the – the weather pattern change? Why is it warm sometimes, cool some other times? What are the objects in my environment? Why is this heavy? Why is this light? Why does this crumble? How come when I mix water and mud it turns into something else? How come certain things when I'm taking a bath float and other things sink?

Well, if you think about this, this is science. So in some sense, science is already drawing on children's natural curiosity about the things they want to understand, which is the world around them. Another question: isn't preschool too early to start teaching science? Well, we now have research. Relatively recently it used to be thought that science was – preschool was too early to teach science. But young children are really capable of scientific thinking and they can use this as a model to guide learning not only in science but in other areas.

Next question: if I'm going to teach science, don't I need to be an expert? Children are going to ask me lots of questions I can't answer. How can I do science? Well, in actuality, when you look at science, much of it – much of the activities involves hands-on approaches, which teachers and people in preschool are very comfortable doing hands-on. Children are very comfortable doing hands-on. And when children do ask questions, you don't need to know what the answer is because science is also a process for answering questions. So when a child asks a question, you can say, "Boy, that's a good question. What can we do together to figure out the answer?" And science lends itself and provides ways of answering questions so you don't need to know what the answers are going into whatever the lessons are.

How do I have time for science with so many other important other readiness domains to cover? We know children have very short attention spans, it's a short day, and there's now 11 of these things to cover. Well, one of the answers is don't do them one at a time. Try to think about how these can be done together. And one of the things you can see about science if you look at it carefully is that science really is a great way for solving this "coverage" problem. It's an ideal domain for integrating other readiness areas.

Now, I see that I'm beginning to run out of time, so I'm not going to read all of these to you, because you'll have access to these slides and to the videotape. But language and literacy is something you could easily do as part of science lessons because there's books to read, there's things to document. There's counting and measuring and comparing and making charts, so there's math. Science is done in – in small groups. You have to share information, so it promotes social development. The activities involve fine and gross motor skills, so you're developing physical development. There's opportunities to talk about health. You can do a lot of drawing; kids aren't really writing a lot, but they can draw pictures. You can make creative art projects as part of a particular science lesson.

The social studies component: what's the role of science? Things like protecting the environment, recycling, bringing people into your classroom who are scientists, as examples. Understanding what science is as possible career and how science plays a role in society. Logic and reasoning is clearly something that – that is required for young kids to do the problem solving within science. Approaches to

learning: the children are already curious about their world. If you're curious and engaged and interested, you're likely to persist longer, to show flexibility in trying to answer questions, especially if they're questions generated by the children themselves. And science, again, is a fertile ground for learning new vocabulary, for communicating. So it encourages children, even those that don't have proficiency in English, to begin to express themselves, to learn new words, and to develop language skills.

So I want to finish by saying that there are already lots of ideas and activities that you can start with. So there is, as I said, two prior talks; there are resources associated with that. The Office of Head Start has done a number of webinars and has resources available. The National Center on Quality Teaching and Learning also has resources available on science. So there's lots of ideas and activities for you to start.

Now, I'm hoping that you now feel that it's time to move science from an unwelcomed guest, if that's the case, to your very best friend. And there are, as I said, resources to get you started. And once you dive into it, you'll see that the water is quite warm and there's salt, so it's easy to float. In the meantime, in terms of this being stay tuned, there's a lot going on now in science. Science as – as a research area is not as well developed as what we know about language and literacy or even math, but there's now great interest in science.

As you've seen, this is the third presentation on science. And there are science programs, some of which are freestanding, some of which are add-ons to existing curricula, like Creative Curriculum and HighScope, that are currently being developed and evaluated. And also, there's a variety of assessments that are being developed so that you can determine, you know, are teacher's attitudes important? Are they changing? What are the children's attitudes? What are the instructional practices? Are these good practices? What are children learning? These are always – also being developed and evaluated.

And I'll just show you one quick slide. This is a picture of the computer adaptive assessment system that we're currently developing. We have about another year to go and we'll have this finished. But children put on headphones – Janna's actually the voice of our science assessment – and the children respond. They'll hear, for example, the picture of – of the strawberry and the ice cube at the top that's not highlighted first appears, and Janna will say, "What will happen when this ice cube is heated?" Then the three pictures below appear. "Touch the picture of what will happen." The child chooses one, and this ends up being an adaptive test and we can relatively quickly determine the child's ability in a very fun and engaging environment that the children are actually upset when the test is over.

So I'm going to end, since I've already talked a little bit more than half an hour, and hopefully we still have time to answer some questions.